# CHAPTER 8

# ALARM SYSTEMS

## INTRODUCTION

Many buildings and complexes being constructed today are equipped with some type of intrusion detection and fire-alarm systems. You, as a Construction Electrician, will be challenged to install, troubleshoot, and maintain these systems. Numerous detection and fire-alarm systems are in existence today. In this chapter, we will discuss the function and operation of a typical detection system and various fire-alarm systems. When you are in charge of the installation or maintenance of either a detection or a fire-alarm system, you should acquire reference material, such as manufacturer's literature. If such material is unattainable, refer to Maintenance of Fire *Protection Systems,* NAVFAC MO-117, that provides an excellent description of several fire-alarm systems. *Commercial Intrusion Detection Systems (IDS),* Design Manual 13.02, provides descriptions ofvarious intrusion detection systems.

The purpose of any alarm system is either to protect life or property or to detect an intrusion. Alarm systems are set up to (1) give early warning so occupants may evacuate the building and (2) notify the fire department and/or security so they can react as soon as possible.

This chapter will increase your knowledge about security/fire-alarm system installation techniques, operations, and maintenance.

## INSTALLATION TECHNIQUES

Before the installation of a security/fire-alarm system is started, a sketch of the building should be prepared or the original blueprints should be obtained. This sketch should be drawn to scale and should show the location of all windows and doors, chases, closets, and so forth. A simple riser diagram showing the various components, such as smoke and heat sensors, control panel, and alarm signals, should also appear on the sketch. When this is completed, the installer can begin the design of the security/fire-alarm system. As a Seabee, it is important to check all supporting documents in the manufacturer's manual before installing a system. If you encounter a problem, contact the NAVFAC alarm systems coordinator.

## TYPES OF FIRE-ALARM SYSTEMS

Building alarm systems may be local or local with base alarm system connections. They may be coded or noncoded and may operate either on line-voltage or low-voltage electric power. Their characteristics are described in the following paragraphs.

### Coded Alarm Systems

A coded alarm system has audible or visual alarm signals with distinctive pulsing or coding to alert occupants to a fire condition and the location or type of device that originated the alarm. Coding the audible appliances may help personnel to distinguish the fire-alarm signal from other audible signals. Clear and early recognition of the signal should encourage a more orderly and disciplined evacuation of the building. A common characteristic of coded alarm systems, especially of selective coded and multiplex coded systems, is that the coded alarm identification provided by the audible alarm signals is not repeated continuously. Normally, after four complete repetitions of the coded signal, the coding process ends.

### Noncoded Alarm Systems

A noncoded alarm system has one or more alarm-indicating appliances to alert the building occupants of a fire but does not tell the location or the type of device that has been activated (manual alarm or automatic protection equipment). The audible or visual alarm appliances operate continuously until they are turned off, until a predetermined time has passed, or until the system is restored to normal. The location or type of device originating the alarm condition can be determined by using an annunciator system. An annunciator is a visual-indicating device.

## NATIONAL ELECTRICAL CODE REQUIREMENTS FOR SECURITY/ FIRE-ALARM SYSTEMS

Because of the potential fire and explosion hazards caused by the improper handling and installation of electrical wiring. certain rules in the selection of materials and quality of workmanship must be followed as well as precautions for safety,. The *National Electrical Code® (NEC®)* was developed to standardize and simplify these rules and provide some reliable guide for electrical construction.

The *NEC®* is published (and frequently revised) by the National Fire Protection Association (NFPA), Batterymarch Park. Quincy, MA 02269. It contains specific rules and regulations intended to help in the practical safeguarding of persons and property from hazards arising from the use of electricity,, including low voltage. used in the majority of security/fire-alarm systems.

Article 725 of the NEC® covers remote-control. signaling, and power-limited circuits that are not an integral part of a device or appliance. The *NEC®* (section 725-1) states:

> The circuits described herein (Article 725) are characterized by usage and electrical power limitations that differentiate them from light and power circuits and. therefore. special consideration is given with regard to minimum wire sizes, derating factors, overcurrent protection, and conductor insulation requirements.

Personnel assigned to install security/fire-alarm systems should become familiar with Article 725 of the NEC® as well as Article 760, "Fire Protective Signaling Systems." This article covers the installation of wiring and equipment of fire-protective signaling systems operating at 600 volts or less.

Other *NEC®* articles of interest to security/fire-alarm installers include the following:

1. Section 300-21, 'Spread of Fire or Products of Combustion."

2. Articles 500 through 516 and Article 517, Part G (dealing with installations in hazardous locations).

3. Article 110, "Requirements for Electrical Installations" and Article 300. "Wiring Methods."

4. Article 310. -"Conductors for General Wiring."

5. Fire-protectile signaling circuits and equipment will be grounded according to Article 250, except for dc-power limited fire-protective signaling circuits that have a maximum current of 0.03 amperes.

6. The power supply of nonpower-limited fire-protective signaling circuits will comply with chapters 1 through 4 and the output voltage will not be more than 600 volts, nominal.

7. Conductors of No. 18 and No. 16 sizes will be permitted to be used provided they, supply loads that do not exceed the ampacities given in table 402-5 and are installed in a raceway or a cable approved for the purpose. Conductors larger than No. 16 will not supply loads greater than the ampacities given in tables 310-16 through 310-19.

8. When only nonpower-limited fire-protective signaling circuits and Class 1 circuits are in a raceway, the number of conductors will be determined according to section 300-17. The derating factors given in Note 9 to tables 310-16 through 310-19 will apply if such conductors carry continuous loads.

9. Where power-supply conductors and fire-protective signaling circuit conductors are permitted in a raceway according to section 760-15, the number of conductors will be determined according to section 300-17. The derating factors given in Note 8 to tables 310-16 through 310-19 will apply as follows:

a. For all conductors when the fire-protective signaling circuit conductors carry continuous loads and the total number of conductors is more than three.

b. For the power-supply conductors only when the fire-protective signaling circuit conductors do not carry continuous loads and the number of power-supply conductors is more than three.

10. When fire-protective signaling circuit conductors are installed in cable trays. comply with sections 318-8 through 318-10.

## UNDERSTANDING BASIC INSTALLATION OF SECURITY/ FIRE-ALARM SYSTEMS

The installation of a protective security/fire-alarm circuit should always start at the protective-circuit energy source, as if it were an end-of-line battery-a battery. remote from the control panel-even though it may actually be a power supply installed in the panel. A pair of wires is run from this power source to the first contact location, but just the positive wire is cut and

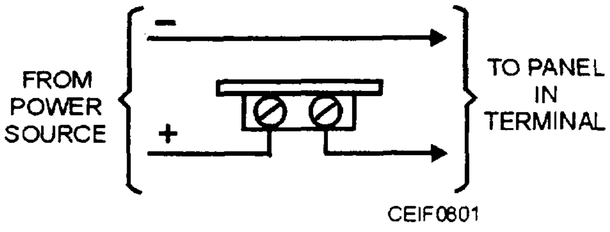


**Figure 8-1.—Contacts are connected into the positive wire only. Break positive wire only at door contacts.**

connected to the two contact terminals, as shown in figure 8-l. The neutral or common wire is not cut but continues on in parallel with the positive or "hot" wire. The pair is then run on to the next contact-a door, window, or sensor-and again only the hot wire is connected to the contacts. This procedure is repeated until all contacts are wired in series, and then the pair of wires is run from the last contact device on the system to the protective-circuit terminals in the panel. Although the markings will vary from manufacturer to manufacturer, the terminals for the starting connections will read something like LOOP POWER OUT, while the terminating terminals will read IN, or a similar term.

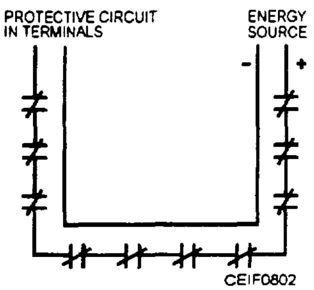


**Figure 8-2.—Negative conductor is run with a positive conductor to all contacts, even though the system would operate with just a single-wire, positive-leg wire run from contact to contact.**

A simple circuit of the wiring connections just described is shown in figure 8-2. Obviously, the system would operate with just a single-wire, positive-leg circuit run from contact to contact, with the negative power-supply terminal connected directly to the negative protective-circuit terminal within the cabinet. However, manufacturers discourage this practice since troubleshooting a single-wire circuit can be extremely time consuming. and the single wire is more vulnerable to defeat by an intruder with no trouble symptoms occurring to warn the user of the loss of protection.

An exit/entry delay relay is sometimes used on security systems so that authorized personnel may exit and enter (using their door keys) without activating the alarm. However, a shunt switch is more often preferred (fig. 8-3). The purpose of the shunt lock is to enable an authorized person with a key to shunt out the contacts on the door used for exit/entry, allowing him or her to enter or leave the premises without causing an alarm when the alarm system is turned on. The shunt lock does extend outside the protected premises; however: it is a potential weak link in the system. Following the two procedures suggested below makes defeat of the shunt lock much more difficult:

1. Install the shunt lock at the door that is most brightly illuminated and most readily visible to passersby.

2. Wire the shunt lock switch to the magnetic contact terminals, as shown in figure 8-4. This arrangement traps the lock so that any attempt to pull it out to gain access to its terminals will break the positive side of the protective circuit and cause an alarm to sound.

Contacts used to signal the opening of doors, windows, gates, drawers, and so forth are usually mounted on the frame of the door or window, while

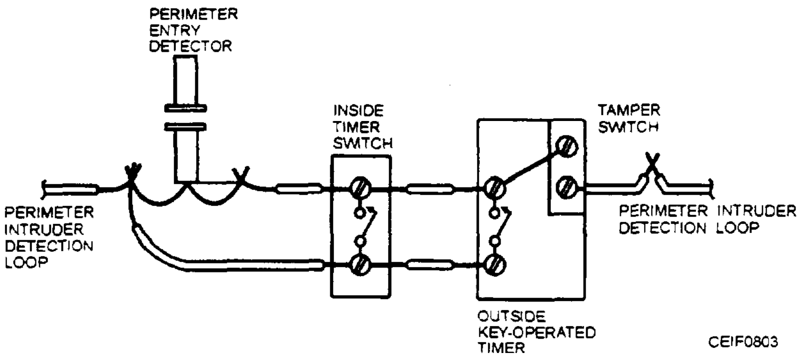


**Figure 8-3.—Typical shunt switch circuit.**

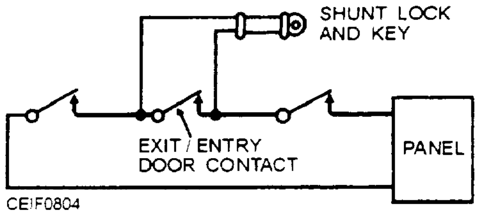


**Figure 8-4.—Wire the shunt lock switch to the magnetic contacts as shown.**

the magnet unit is mounted on the door or window (moving part) itself. The two units should be positioned so that the magnet is close to and parallel with the switch when the door or window is closed. This keeps the shunt lock actuated, but opening the door or window moves the magnet away and releases the switch mechanism.

As long as the faces of the switch and magnet are parallel and in close proximity when the door or window is closed, they may be oriented side-to-side, top-to-top, or top-to-side. Mounting spacers may be used under the units if necessary to improve their alignment and proximity.

Terminal covers are available for most makes of door contacts to give the installation a more finished look and also to protect the terminal connections against tampering.

The wiring of any alarm system is installed like any other type of low-voltage signal system; that is, one must locate the outlets, furnish a power supply. and finally interconnect the components with the proper size and type wire.

## ALARM SYSTEMS INSTALLED IN EXISTING BUILDINGS

Many changes and advances in developing complete security/alarm systems for building operation and protection have taken place in the past few years. Numerous existing buildings are currently having security and fire-alarm systems installed either to replace their obsolete systems or to provide protection they never had.

The materials used for installing a complete alarm system in an existing building are essentially the same as those used in new structures. However, the methods used to install the equipment and related wiring can vary tremendously and require a great deal of skill and ingenuity. Each structure is unique.

When concealed wiring is to be installed in a finished existing building. the installation must be planned so that the Least amount of cutting and patching is necessary. In most cases, this means giving special consideration to the routing of conductors. Unlike the wiring of a new building where the installer would try to conserve as much material as possible, the amount of material used (within reason) is secondary in existing buildings. The main objective in security/fire-equipment installations in existing buildings is to install the wiring in the least amount of time with the least amount of cutting and patching of the existing finishes of the building.

Before any actual work on an existing building is started, the contractor or the installers should make a complete survey of the existing conditions in the areas where the security system will be installed. If the majority of the work can be done in exposed areas (as in an unfinished basement or attic), the job will be relatively simple. On the other hand, if most of the wiring must be concealed in finished areas, there are many problems to be solved. The initial survey of the building should determine the following:

1. The best location for the alarm control panel.

2. The type of construction used for the exterior and interior walls, ceilings, floors, and so forth.

3. The location of any chases that may be used for routing the conductors and the location of closets, especially those located one above the other for possible use in fishing wires.

4. The material used for wall and ceiling finishes—plaster, drywall, paneling, and so forth.

5. Location of moldings, baseboards, and so forth, that may be removed to hide conductors.

6. Location of decorations or other parts of the building structure that cannot be disturbed.

7. Location of any abandoned electrical raceways that new alarm system wires might be fished into. Do not overlook similar possibilities. For example, an old abandoned gas line can be used to fish security-system wires in an old building.

8. The location of all doors and windows, coal chutes, and similar access areas to the inside of the building.

As indicated previously, the most difficult task in running wires in existing buildings is the installation of concealed wiring in finished areas with no unfinished areas or access to them. In cases like these. the work is usually performed in one of two ways. First by deliberately cutting the finished work so that the new wiring can be installed. Of course. these damaged areas must be patched once the wiring is installed. The second way is to remove a small portion of the finished area (only enough to give access to voids in walls, ceilings, etc.) and then fish the wires in. The removed portions of the finished area are then replaced after the wiring is complete.

Where outlet boxes are used, they should be designed for installation in the type of finish in the area. Means of securing the boxes to some structural member-like mounting ears or holding devices-should be given consideration.

Another method of providing outlets in a finished area is to remove the existing baseboard and run the conductors in the usual groove between the flooring and the wall and then replace the baseboard. This method requires less work (cutting and patching) than most other methods when disturbing a finished area. There is also a type of metal baseboard on the market that may be installed along the floor line and used as a raceway. Most types are provided with two compartments for wires: one for power and one for low-voltage wiring. Using this metal baseboard provides a simple means of routing wires for security/fire-alarm systems with very little cutting or patching. In most cases, wires can be fished from the baseboard up to outlets on the wall, especially if the outlets are less than 3 feet (0.9 m) above the floor. However, if this is not practical, matching surface molding can be installed to blend in very nicely with the baseboard.

When a lot of cutting and patching is required in a finished area, many installers will have a carpenter do the work. The carpenter may know some tricks that will help the alarm-system installers get the system in with the least amount of difficulty. Also, any cutting or patching will be done in a professional manner.

Before doing any actual cutting on an existing building to install security/fire-alarm components, the installer should carefully examine the building structure to ascertain that the wires may be routed to the contacts and other outlets in a relatively easy way. It is possible that a proposed outlet location, for example, could be moved only a foot or two to take advantage of an existing chase. Perhaps a smoke detector or similar component was originally located in a ceiling with insulation, which would make the fishing of cables very difficult. If the detector could be located on a ceiling containing no insulation, the job would be greatly simplified.

When cutting holes in ceilings for outlets, you should spread a drop cloth or paper underneath to catch all dust and dirt. Sometimes an old umbrella can be opened and hung upside down under the spot in the ceiling where the hole is being made to catch the debris and keep it off the rugs and furniture.

Holes for wires and components can be cut through plaster with a chisel, through wood with a keyhole saw after first drilling two or four pilot holes, and in brick or other masonry with a masonry chisel or rotary hammer. To locate the exact spot to cut these openings, first cut a small hole in the center of the spot where the larger one will be made. This hole may then be used to locate the area between studs or--in the case of very old buildings--the cracks between the plaster laths. It is then possible to shift the mark for the outlet openings so that all obstacles can be avoided and the outlet box or component can be properly anchored.

There are a number of ways to pull and fish wires into walls and openings in finished buildings and, with a little ingenuity and careful thought, workers should be able to solve almost any problem of this kind that they may encounter.

When you are pulling wires into spaces between the joists in walls, a flashlight placed in the outlet box hole is often a great help when feeding the wires in or catching them as they are pushed near the opening. Under no circumstances should a candle or other open flame be used for this purpose. If one must see farther up or down the inside of a partition, a flashlight and a mirror used in combination, as shown in figure 8-5, is a great help. Many installers like to make their own mirror by gluing a small 2- by 3-inch (5- by 8-cm) compact mirror on a handle, resembling a wooden tongue depressor. Any type of small flashlight may be used.

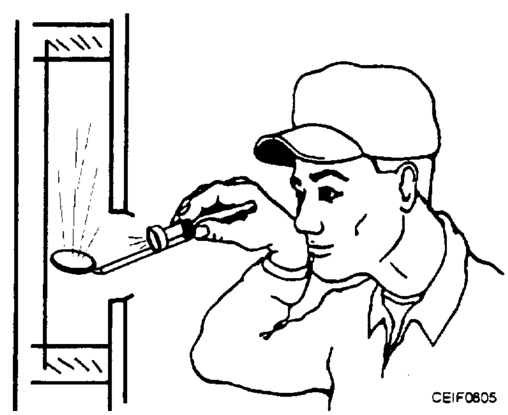


**Figure 8-5.—A flashlight and mirror used in combination are useful for viewing conditions inside of partitions.**

## NEW TECHNIQUES FOR INSTALLING SECURITY/FIRE-ALARM SYSTEMS IN EXISTING BUILDINGS

Presently available are tools that make it much easier to install security/fire-alarm systems in existing buildings. You may now attach a drill bit to a long, flexible spring steel shaft. This makes it possible to easily manipulate a drill bit in walls to accomplish complex installation maneuvers in existing buildings. There are some other tools that are helpful with cable installation. An alignment tool may be used to hold the bit and shaft steady while drilling. Line recovery devices grip the holes located in the shaft end of the drill, thus, allowing one person to quickly fish wires or cables through partitions and shaft extensions.

Where it becomes necessary. to remove floorboards during a security/fire-alarm installation. it should be done with the greatest of care so that the edges are not split. On the finished job, when the boards are replaced, split edges make a poor appearance Special saws may be purchased for cutting into floors or other surfaces without having to drill holes to start the saw. Then if the tongue (on tongue-and-groove boards) is split off with a thin, sharp chisel driven down in the crack between the boards, the board from which the tongue was removed can be pried up carefully without damaging the rest of the floor.

## NEW TECHNIQUES AND PROCEDURES FOR OPERATING EQUIPMENT

If at all possible. a reversible drill motor should be used to withdraw the bit from the wall. The motor should be running only when the bit is actually passing through a wood member. When you are drilling, force is exerted in one direction. When the bit is being removed. it is removed at a different angle and force is exerted from a different direction. This is why the reverse is used. If the flexible shaft is being used with drill motors with no reverse, it would be better to exert force to pull the bit from the hole with the motor running because chances of an easy recovery without damage are much better with the motor running.

When you are drilling from an attic or crawl space, be certain not to select an area directly above or below a door since this will result in property damage. It is also good to keep a slight tension on the wire when it is being pulled from overhead so that it will not get tangled with the bit and become damaged.

The shaft should not be bowed any more than absolutely necessary to accomplish the job. Excessive bowing will decrease the life of the flexible shaft. Drill motors, of course. should be adequately grounded or else have insulated handles.

## PUTTING NEW TECHNIQUES INTO PRACTICAL APPLICATIONS

Assume that an outlet box for an infrared photoelectric detector is to be installed above a countertop in a residential kitchen to sense entry of unauthorized persons through the kitchen door. If. upon investigation of the space inside of the partitions, it is found that a 2- by 4-inch (5- by 10-cm) wood member (fire stop) blocks the route from the outlet hole to the basement area where the alarm control station is located, an alignment tool must be used.

The flexible shaft, containing a drill bit. is placed through a cut outlet-box opening and then the special alignment tool is attached to the shaft, as shown in figure 8-6. The shaft will bow back toward the operator by keeping the alignment tool in the same position to the shaft and by lifting the handle. As the bit is lowered into the wall cavity, the operator can feel the bit strike the inside wall. When the bit is aligned correctly on the wooden member, the alignment tool is removed while keeping downward pressure on the bit so that it will not slip out of place, and the hole is drilled through a fire stop. This hole will then act as a guide for drilling through the floor plate, as shown in figure 8-7.

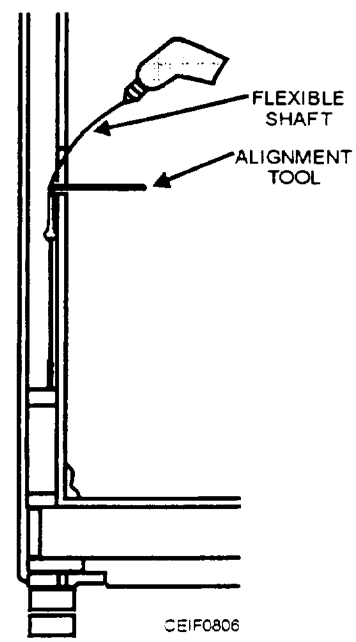


**Figure 8-6.—The alignment tool is attached to the shaft, ready for operation.**

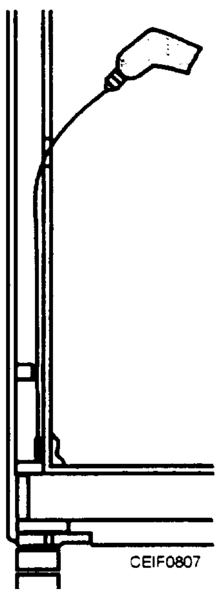


**Figure 8-7.—The first hole cut acts as a guide for drilling through the floor plate.**

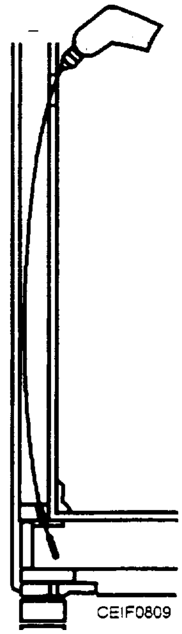


**Figure 8-9.—Bit has penetrated into basement area.**

In the case of a wall cavity without tire stops or purlins, the alignment tool is used to snap the bit back to the inside wail (fig. 8-8) at which time downward pressure on the drill motor will keep the bit point in place and cause the shaft to bow. Power and pressure are then transmitted from the back wall that allows proper angle drilling to miss the joint boxing.

After the bit has penetrated into the basement area, as shown in figure 8-9, the operator has access to the hole in the drill bit itself for attaching the recovery grip and pulling the wire up to the outlet location-all without damage to existing finishes.

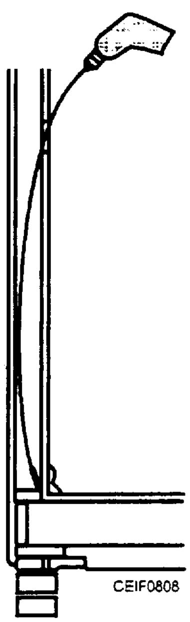


**Figure 8-8.—Alignment tool used to snap the bit back to the inside wall.**

Figure 8-10 shows how the recovery grip is attached to the bit tip eyelet. The swivel, located between the cable and the head of the grip, prevents the wire or cable from becoming twisted during the fishing process.

Figure 8-11 shows the grip after it has been attached to the bit tip with the line inserted, ready for recovery. The operator uses the drill motor in reverse and applies a slight pull. The wire then can be pulled easily through the holes because of the reverse cutting action of the bit. If desired, the drill motor can be removed from the shaft and a recovery grip attached to the chuck end of the shaft for pulling the wires downward toward the basement. While this example shows the method of routing wires or cables from an outlet to a basement, the same procedure would apply for drilling from an outlet opening to an attic space.

To install contacts on windows for a burglar-alarm system, drill from the location of the contact through the casement, lintels, and plates with a 3/8-inch (0.9-cm) shaft. Attach a recovery grip to the end of the bit, insert the wire to keep the grip from becoming tangled, reverse the drill motor, and bring the wire toward the operator as the bit is being withdrawn.

Burglar-alarm contacts or door switches installed at doors are simple projects when one uses the flexible shaft. First cut or drill the entrance hole in the normal manner and then insert the flexible shaft with bit into

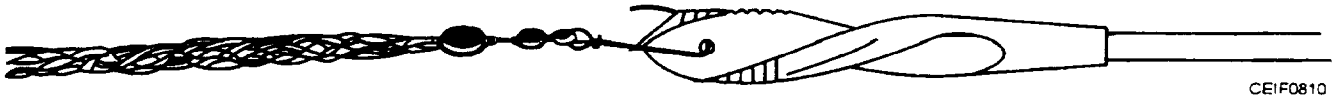


**Figure 8-10.—Recovery grip attached to the bit tip eyelet.**

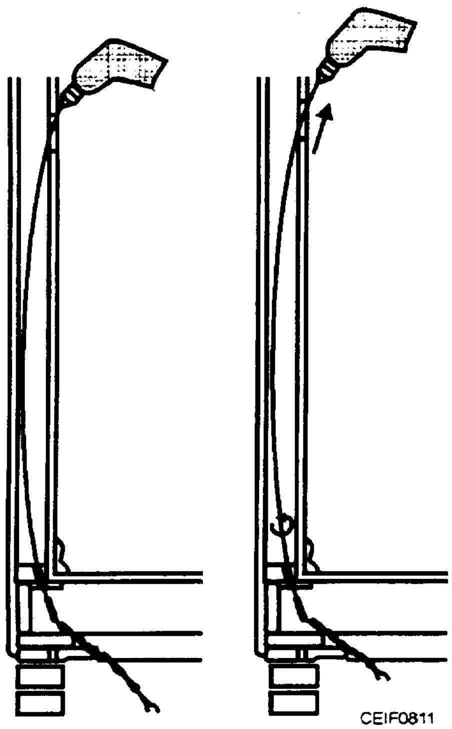


**Figure 8-11.—Grip attached to the bit tip with the line inserted, ready for recovery**

the entrance hole, slanting the bit as much as possible in the desired direction of travel. Continue by drilling through the door casing and floor jamb into the cavity of the wall, as shown in figure 8-12, view A. A similar procedure is followed when drilling for window installation as shown in figure 8-12, view B. The drill is then stopped until it strikes the next stud that will deflect the bit either up or down, depending on the direction of the drilling. Continue to push the bit until it strikes the top of the bottom plate and then drill through the plate into the basement or attic. The recovery grip is then attached to the bit and the wire or cable may be drawn back toward the operator by reversing the drill motor and keeping a slight tension on the wires, as they are being pulled to prevent tangling.

With conventional tools, the routing of wires from one outlet to another, as shown in figure 8-13, requires either channeling the wall; using wire mold; or running the wires down to the baseboard, removing the baseboard, and then installing the wires behind it. Instances like these occur when the crawl space is too shallow for workers to crawl into or the house is built on a concrete slab. However, with the flexible shaft, it

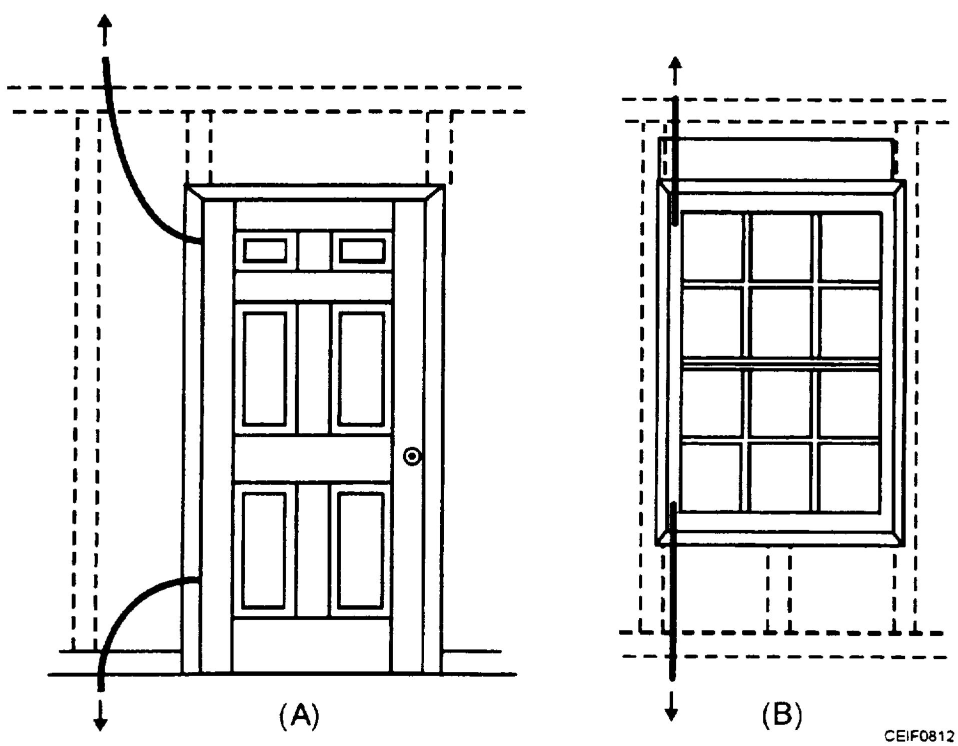


**Figure 8-12.—Drilling through the doorjamb (A) and window casing (B) into the cavity of the wall.**

is possible to drill through the wall horizontally through several studs (if the operator is careful) and then pull the wires back through the holes to the openings.

The installation of an outside annunciator under the eave of a house with an extremely low pitch to the roof would cause several problems in getting wires to the outlet. With the flexible shaft, a hole can be drilled through the boxing, as shown in figure 8-14. As soon as the bit penetrates the boxing, it is pushed into the attic as far as it will go. A recovery grip is then attached to the bit, the wire or cable inserted, and then pulled backward toward the outlet opening. The outlet box and annunciator (horn, bell, etc.) are installed under the eave and the other end of the cable is connected to the alarm system. Also, because the flexible shaft is more rigid than the conventional fish tape, it will penetrate attic insulation if any exists.

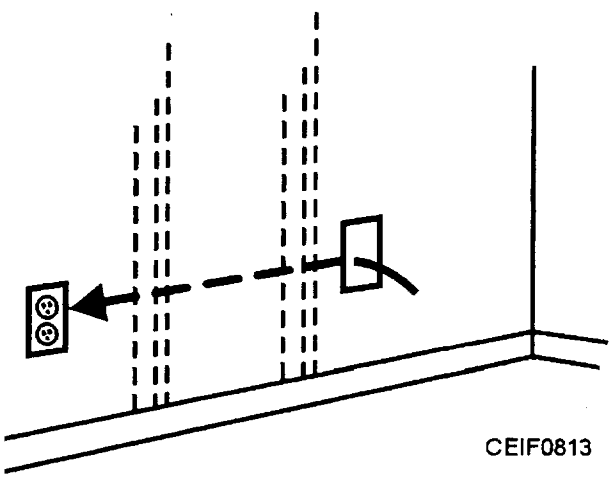


**Figure 8-13.—How wires must be routed when one uses conventional tools.**

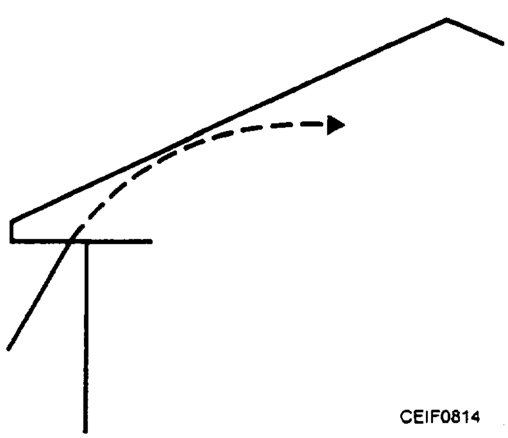


**Figure 8-14.—Method of drilling a hole through boxing by using a flexible shaft.**

If it becomes necessary to install wiring in an attic and run cable from this area to the basement, the installation can be greatly simplified by using a flexible shaft. First drill through the top plate into the wall cavity, making sure that the drilling is not being done above a window or doorway or any other obstruction, such as existing wiring, ductwork, and so forth. Once through the top plate, the drill motor is turned off and the bit is pushed into the cavity of the wall as far as it will go. If no fire stops are encountered, the bit is pulled back and an extension is attached to the shaft. With the extension installed, the bit is again lowered into the wall cavity until a fire stop is encountered. The bit is then positioned and used to drill through the wooden member. Once the wooden member is penetrated, the drill motor is again stopped and the bit is lowered further until the bottom plate is reached. Continue drilling through the bottom plate in the basement or crawl space. Fasten the appropriate recovery grip, insert the wire or cable, and pull up the wire with the flexible shaft. The drill motor should be reversed only when the bit is passing through one of the wooden members.

Those who use the flexible shaft device often are certain to discover many other useful techniques for installing wiring in existing structures.

## COMPONENTS OF SECURITY/FIRE-ALARM SYSTEMS

Wire sizes for the majority of low-voltage systems range from No. 22 to No. 18 AWG. However, when larger-than-normal currents are required or when the distance between the outlets is long, it may be necessary to use wire sizes larger than specified to prevent excessive voltage drop. Voltage-drop calculations should be made to determine the correct wire size for a given application even on low-voltage circuits.

The wiring of an alarm system is installed like any other type of low-voltage system. The process consists of locating the outlets, furnishing a power supply, and finally interconnecting the components with the proper size and type of wire.

Most closed systems use two-wire No. 22 or No. 24 AWG conductors and are color-coded for identification. A No. 18 pair normally is adequate for connecting bells to controls if the run is 40 feet (12 m) or less. Many electricians, however, prefer to use No. 16 or even No. 14 cable.

Some of the various components for a typical security/fire-alarm system are shown in figure 8-15.

## CONTROL PANEL

This is the heart of any security system. It is the circuitry in these control panels that senses a broken contact and then either sounds a local bell or horn or omits the bell for a silent alarm. Most modem control panels use relay type of controls to sense the protective circuits and regulate the output for alarm-sounding devices. They also contain contacts to actuate other deterrents or reporting devices and a silent holdup alarm with dialer or police-connected reporting mechanism.

The control unit also continuously. monitors the condition of the alarm-initiating-and-indicating-circuit wiring and provides a trouble indication in the event of an abnormal condition in the system, such as an ac power failure or a wiring failure.

The control unit is usually housed in a sheet-metal cabinet (fig. 8-16). The control unit usually provides annunciation of signals (telling where a signal originates).

Because all circuits end at the control unit, it is a convenient test location. Test switches (if provided) are usually inside the locked door of the control unit. If the switches are key-operated, they may be on the control unit cover, rather than inside the cabinet.

## POWER SUPPLIES

Power supplies vary for different systems; but, in general, they consist of rechargeable 6-Vdc power supplies for burglar-alarm systems. The power packs usually contain nickel-cadmium batteries that are kept charged by 12-Vac input from a plug-in or otherwise connected transformer to a 120-volt circuit. Better power supplies have the capability of operating an armed system for 48 hours or more without being charged and still have the capacity to ring an alarm bell for 30 minutes or longer. Power supplies are obviously used in conjunction with a charging source and supply power for operation of the alarm system through the control panel.

Many older local alarm systems are powered by alternating current (ac) power only with no provision for standby, battery power. In these cases, two separate ac circuits (usually 120/240 Vac) are used: one to power the fire-alarm system operating circuits and another to power the trouble-signaling circuits of the system. Low-voltage alarm systems, especially, those provided with battery standby power. are most often

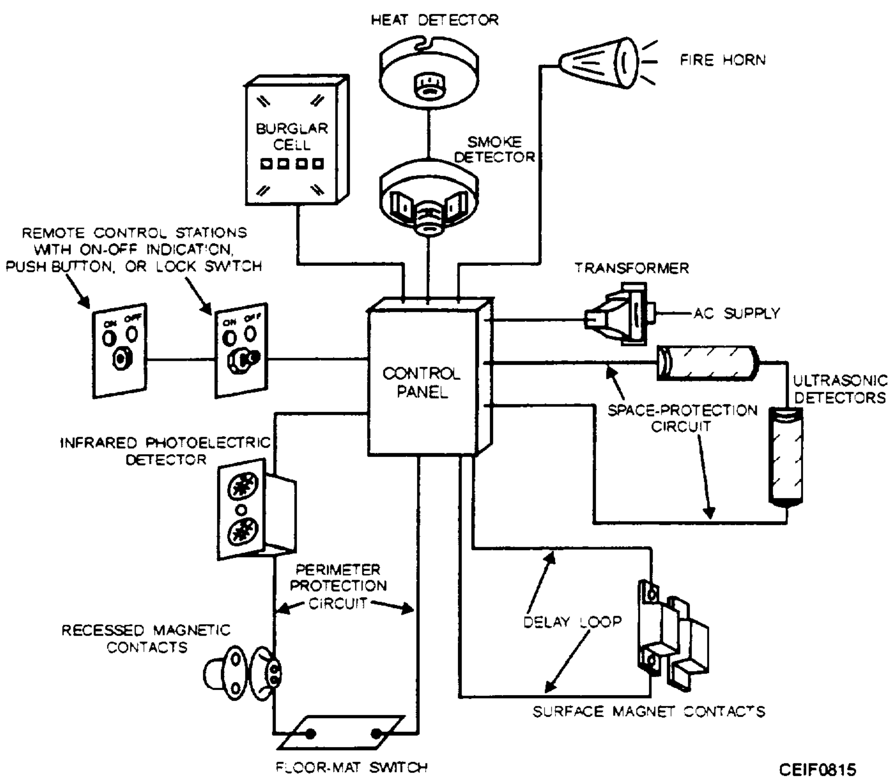


Figure 8-15.—Various components for a typical security/fire-alarm system.

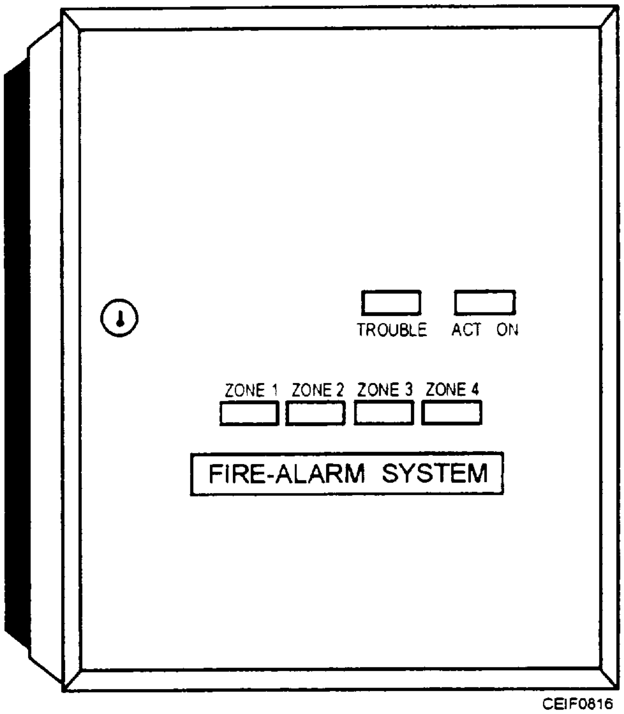


**Figure 8-16.—Control unit with annunciation.**

found where some form of automatic fire detection or automatic fire extinguishing is connected to the alarm system. However, recent conversion by most alarm system manufacturers to solid-state electronic design, which is essentially a low-voltage direct-current (dc) technology, means that the most recent installations are of the low-voltage type.

The power supply of the system refers to the circuitry and components used to convert the ac line voltage to low-voltage ac or dc for operating the alarm system and for charging standby batteries. If the system is an older one with a dry cell, nonrechargeable standby battery (no longer permitted by NFPA standards), the lower supply probably contains a switching arrangement for connecting the battery to the system when ac power fails. Figure 8-17 is a simplified diagram of a typical dc power supply for powering a low-voltage dc alarm system and for charging a rechargeable standby battery.

Transformer T drops the line voltage from 120 volts ac to a voltage in the range of 12 to 48 volts ac. The low ac voltage is rectified by diode bridge D, and the resulting dc voltage powers the alarm system through relay contacts S1 and charges battery B through the current limiting resistor R. When normal ac power is available energizing relay coil S, contacts S1 are closed. If ac power fails, S1 opens and S2 closes, connecting the battery to the alarm system. Fuse F1 protects against a defect in the power supply or the alarm system during normal ac operation. Fuse F2 protects against alarm circuits defects that would cause a battery overload during dc-powered operation.

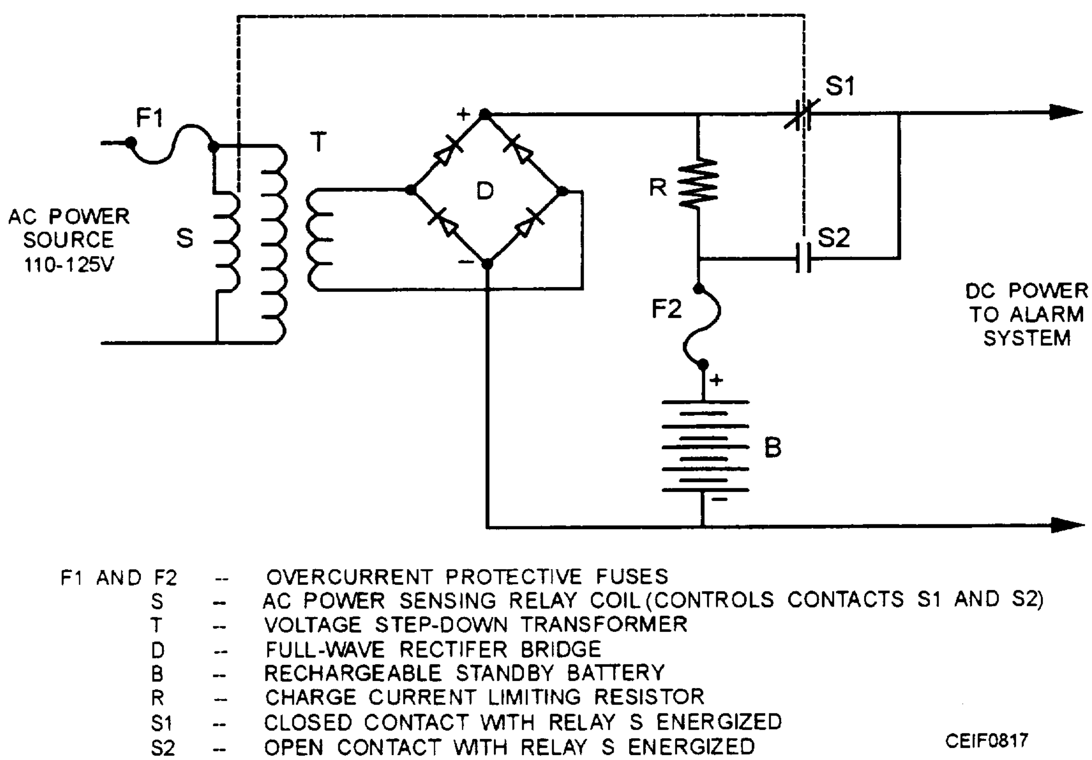


**Figure 8-17.—Typical dc power supply and battery charger.**

Removal of resistor R eliminates the battery-charging feature and allows the use of a dry-cell battery that sits idle until ac power fails. At that time, S1 pens and S2 closes, connecting the battery to the alarm system.

There are many variations of this basic power supply design. These variations add such features as voltage regulation, current limiting, and automatic high-rate/low-rate charging, controlled by the state of the battery charge. All designs normally provide current and voltage meters, pilot lamps, and switches for manual control of charging rate.

## ENTRY DETECTORS

The surface magnetic detector is the most versatile entry detector for residential alarm systems and should be considered first as a method of protecting any movable door or window. These detectors can be mounted on wood, metal, and even glass, if necessary. They can be mounted with screws, double-sided tape, or epoxy. Obviously, the tape and epoxy are useful on glass, aluminum, or any other surface where screws cannot be used. However, when applying tape or epoxy, make certain that the surface is clean, dry, smooth. and at least 65°F (18°C).

### Surface-Mounted Magnetic Contacts on Double-Hung Windows

A switch is mounted on the window casing with a magnet on the window casing and a magnet on the window (fig. 8-18). As long as the switch and magnet are parallel and in close proximity when the window is shut, they may be oriented side-to-side, top-to-side, or top-to-top.

### Surface-Mounted Magnetic Contacts on Doors

Where appearance is not the most important consideration, the use of a surface-mounted switch (on the doorframe) and a magnet (on the door) will simplify installation (fig. 8-19).

### Recessed Magnetic Contacts in Doors and Casement Windows

Where the appearance of surface-mounted systems is objectionable, recess-mounted magnetic protectors may be used. These detectors are more difficult to install and require greater care on the installer's part, but few problems develop if the following precautions are taken.

1. Be careful not to damage or destroy any weatherproofing seal around windows, doors, or other openings.

2. If a recessed-mounted entry detector is installed in the windowsill, you must prevent water seepage to the switch by applying a sealant under the switch flange and around the switch body.

3. When drilling holes to accept each half of the detector, be sure the holes line up. Holes are drilled in the door and in the casing, one directly across from the other, and a pair of wires from the positive side of the

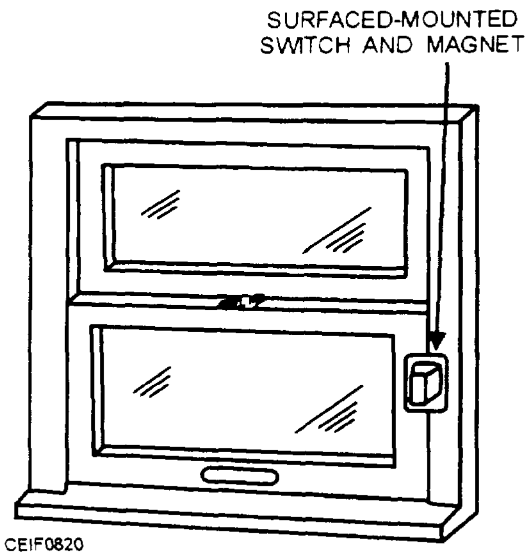


**Figure 8-18.—Double -hung window with surface-mounted magnetic contacts.**

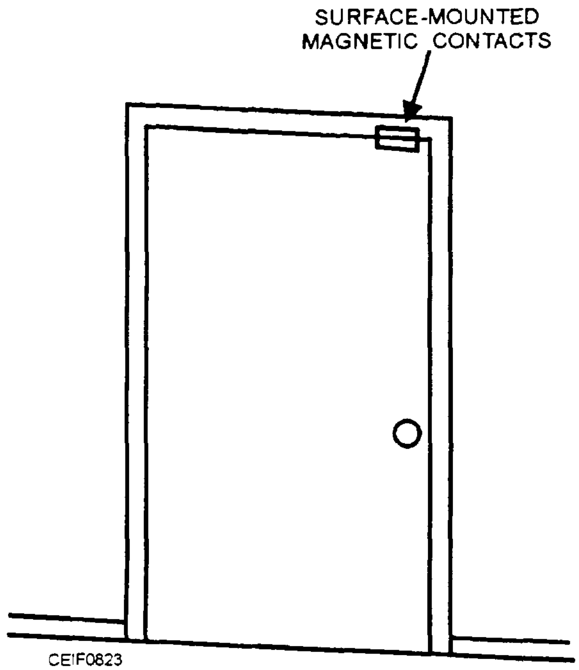


**Figure 8-19.—Surface-mounted magnetic contacts on door..**

protective circuits is run out through the switch hole (fig. 8-20). There should be no more than 1/4-inch (0.6 cm) space for windows and 1/8-inch (0.3 cm) for doors between the two sections of the detector.

4. Be certain there is enough space between the window and its frame (or door and its frame) when each is closed; that is, there must be enough space (usually equaling 1/16 inch or 0.16 cm) for the protrusion of both sections when they meet.

5. A switch and magnet are installed preferably in the top of the window and underside of the upper window casing, where they will be least noticeable (fig. 8-21). If the window frame is not thick enough to accept the magnetic section of the detector, the detector can be mounted in the side frame.

### Conductive Foil on Glass Doors

A self-adhesive foil block (terminator) on the door is connected to a similar unit on the doorframe by a short length of flexible cord to allow for door movement (fig. 8-22). The foil is connected in the positive conductor of the protective circuit and is adhered to the glass parallel to and about 3 inches (7.6 m) from the edge of the glass, using recommended varnish. Breaking the glass breaks the foil and opens the circuit. A double circuit of foil may be taken from the foil block to provide more coverage. Coiled, retractable cords are available for use between foil blocks to allow for sliding-door travel.

### Conductive Foil on Picture Window

Where a window does not open, a single run of foil is connected to a foil block on the glass, frame, or wall (fig. 8-23). When the foil crosses over a frame member, a piece of plastic electrical tape should be used to provide an insulated crossover surface for the foil.

### Complete Glass-Door Protection

A glass door with a glass transom may be protected by a combination of magnetic contacts and foil (fig. 8-24).

### Recessed Plunger

The recessed plunger detector shown in figure 8-25 is mounted so that the door or window will contact the plunger at the tip and push the plunger straight in. Therefore, the area of the window or door that depresses the plunger should have no slots, cutouts, or step-downs into which the plunger might slip. The area also should be hard and free of rubber or vinyl that might be weakened by the plunger and consequently allow the plunger to open. For protecting doors, plunger type of detectors should be mounted only in the doorframe on the hinge side of the door.

### Space Detectors

In cases where it is difficult to protect a window or door by mounting any of the direct type of detectors, the area directly inside the door or window can be protected with interior “space” detectors, such as a floor-mat detector (fig. 8-26) or an ultrasonic motion detector (fig. 8-27).

Floor-mat detectors are easily concealed under rugs at doors, windows, top or bottom of stairways, or any other area onto which an intruder is likely to step. Light pressure on the mat triggers the alarm.

There are also rolls of super-thin floor matting that can be cut to any desired length. These rolls can be used on stair treads and in areas near sliding glass doors or other larger glass areas, entrance foyers, and so forth. In households with unrestricted pets, these mats are almost useless since the pets roam around the home and are certain to step on one of the mats and trigger the alarm.

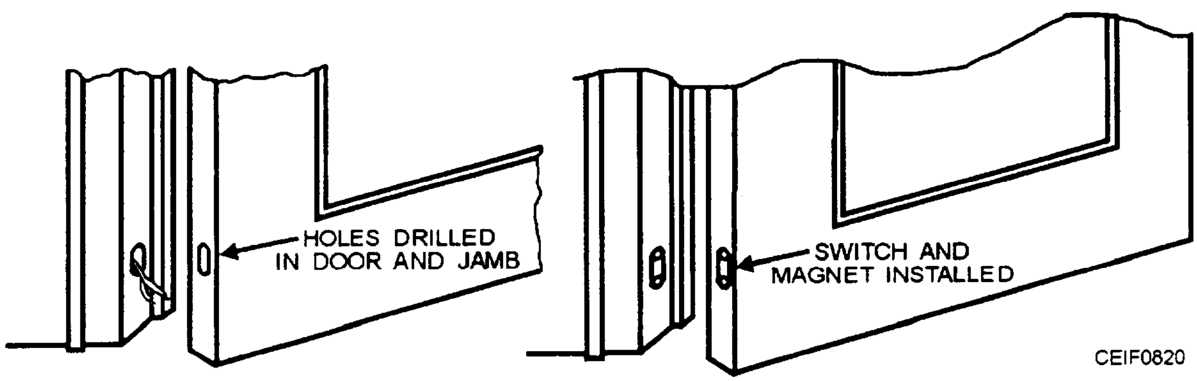


**Figure 8-20.—Recessed magnetic contacts in door.**

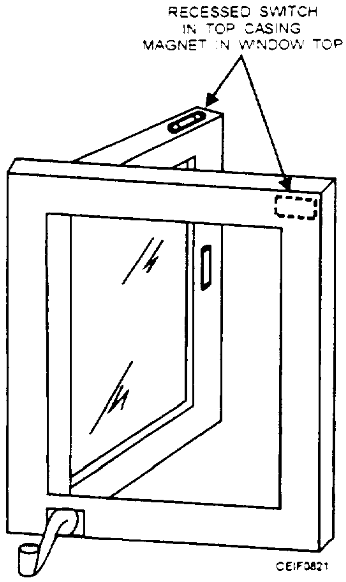


**Figure 8-21.—Recessed magnetic contacts in casement window.**

Other space detectors include ultrasonic motion detectors, audio detectors. and infrared detectors. Care must be used with any of these units because the protected area is limited both in width and depth--depending upon the particular unit.

The ultrasonic motion detector can be used in large glass-walled rooms that might otherwise be difficult to protect and in hallways or entries or in virtually any area an intruder would have to pass through in moving about a home or business. They are especially useful as added protection (when conventional detectors are used also) to monitor a "valuables" room or area.

Most ultrasonic motion detectors are designed for mounting on either the wall or ceiling. It emits inaudible high-frequency sound waves in an elliptical pattern that ranges from 12 feet (4 m) to 5 feet (11 m) long, by 20 feet (6 m) wide, by 5 feet (2 m) high for most residential models. When an intruder moves within the secured area, movement interrupts the established pattern of sound waves and sounds the alarm.

Some designs of motion detectors can be rotated up to 180° for maximum coverage of the area being monitored. as shown in figure 8-28.

Another type of motion detector is the audio detector (fig. 8-29). This type senses certain sharp sounds known to be present in forced entry, such as wood splintering or glass breaking. When these sounds are received through the miniature microphone of the unit, the detector triggers the control unit to sound an alarm.

Audio detectors are best utilized in areas that are seldom used, such as an attic, a garage, or a closed-off wing. They can be used in other areas, but when such areas are subject to much daytime activity, it is recommended that the detector only be armed at night when the business is closed or the family retires or is away from home.

Infrared detectors are another type of motion detector. A combination transmitter-receiver is used to project an invisible pulsating beam at a special bounce-back reflector on an opposite wall. Any interruption of the beam activates the system alarms. Infrared detectors can be wired to either the perimeter or interior circuit; but for faster response, it is recommended that it be connected to the interior circuit.

Infrared detectors are designed for indoor areas, such as entries, hallways, rooms, and so forth. Most cover a span from 3 feet (1 m) to 75 feet (23 m), so it may be used in practically any indoor area or room.

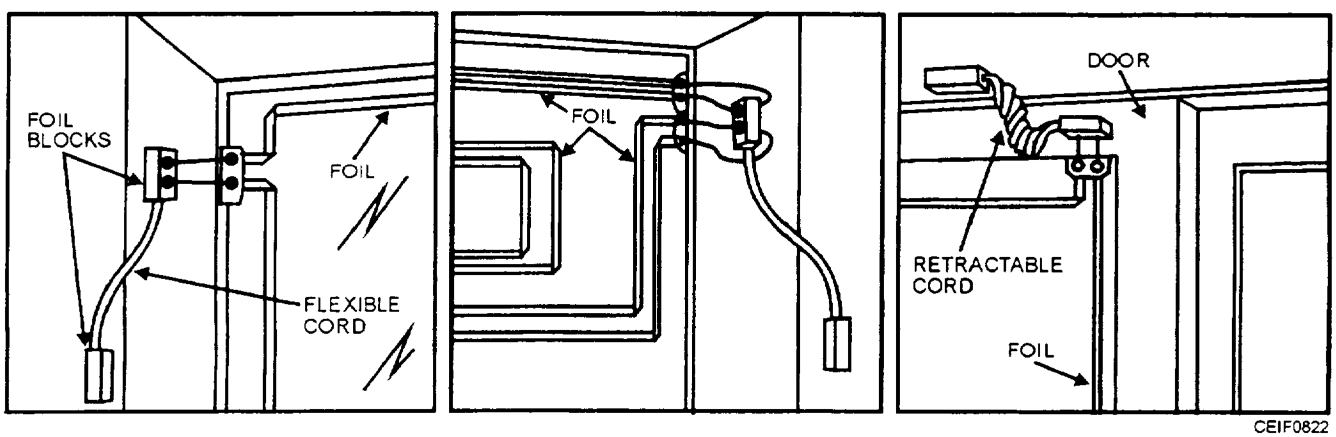


**Figure 8-22.—Conductive foil on glass doors.**

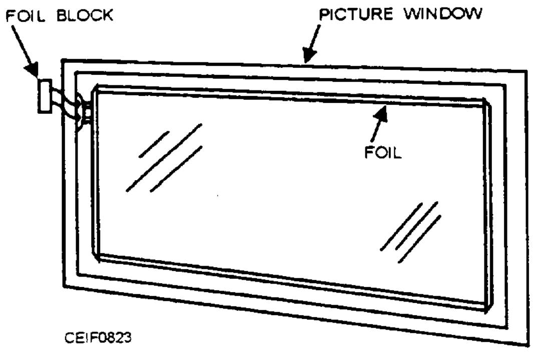


**Figure 8-23.—Conductive foil on picture window.**

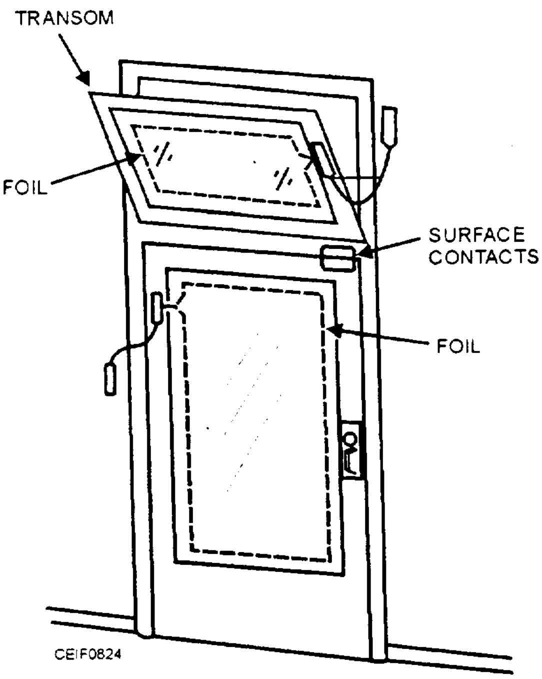


**Figure 8-24.—Complete glass-door protection.**

## ADDITIONAL COMMERCIAL/ INDUSTRIAL COMPONENTS OF SECURITY/FIRE-ALARM SYSTEMS

Industrial security/fire-alarm systems are essentially the same as those used for residential applications. There are, however. a few additional components that are used mostly in industry.

Vibration detectors are often used on industrial buildings to detect vibrations caused by forced entry. Such detectors have been used on a variety of construction materials. such as hollow tile, plaster and lath, brick, concrete. metal ceilings, and wood. Once mounted in place, they may be adjusted with a setscrew for the desired sensitivity.

Some factories maintain a security fence euipped with fence-guard detectors. This type of dectector will detect climbing, cutting, or any other penetration of the fenced area. Most of these detectors operate on standard closed-circuit controls as described previously.

Fence-guard detectors use a vertical-motion detector that is sensitive to movement created by climbing or cutting the fence. Normal side motions, such as wind or accidental bumping, do not affect the detector and cause false alarms. The detectors are normally mounted about midway up the fence and every 10 feet (3 m) of fence length. Most of these devices set off the alarm if they are tampered with or if the wire is cut. They may be connected to a control panel and the alarm will sound in the form of a bell or horn, or it will silently dial the local law-enforcement agency.

Another type of detector that is used is the outdoor microwave detector. This detector is used for protecting large outdoor areas like car lots, construction sites, and factory perimeters. In operation, a solid, circular beam of microwave energy extends from a transmitter to the receiver over a range of up to 1,500 feet (457 m) for some brands. Any movement inside of this beam (fig. 8-30) will activate the alarm.

### Thermistor Sensors

The continuous linear thermal sensor is a small-diameter coaxial wire that is capable of sensing temperature changes along its entire length. The sensor is made up of a center conductor and an outer stainless steel sheath. The center conductor is electrically insulated from the outer sheath by a ceramic thermistor material, as shown in figure 8-31.

Since the thermistor has a negative coefficient of resistance, the electrical resistance between the center wire and the outer sheath decreases exponentially, as the surrounding temperature increases (fig. 8-32).

The changing resistance is monitored by one of several control panels that then can actuate extinguishing systems or any other electrically controlled devices.

Such sensors have a diameter of approximately 0.080 inch (0.2 cm) and, therefore, have a small mass that permits them to sense changes in temperature rapidly. They can sense temperatures from 70°F (21°C) up to 1200°F (649°C) if the thermistor material is properly selected.

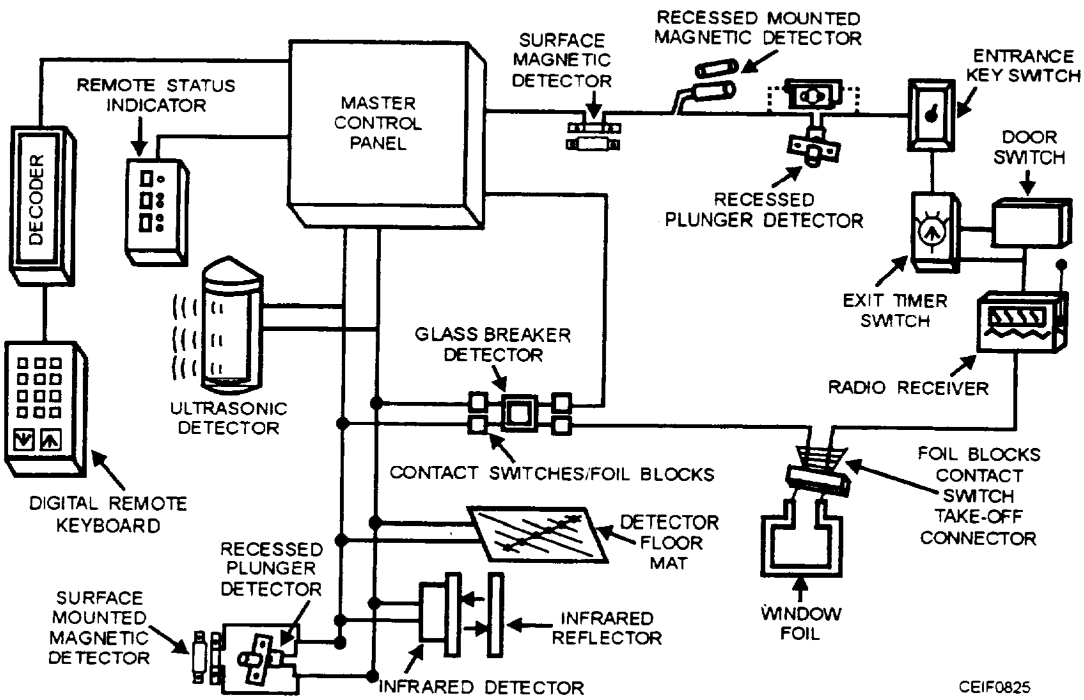


**Figure 8-25.—Various components of a residential security/fire-alarm system.**

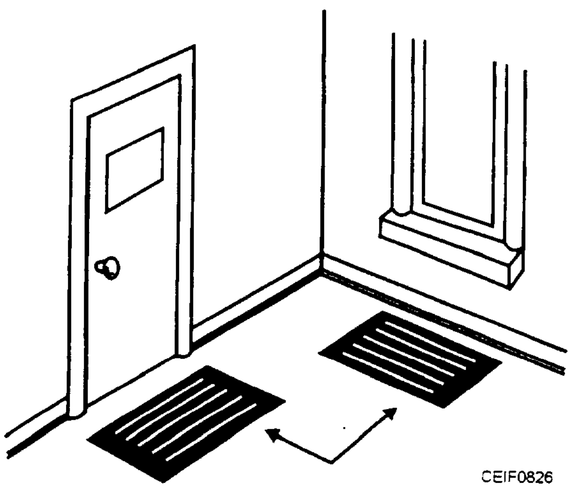


**Figure 8-26.—Floor-mat detector.**

Since electrical resistance is measured across two wires (center and sheath), the sensor has the ability to detect a high temperature on a short wire as well as a lower temperature on a longer one.

The elements are mounted by clamps spaced along their lengths and the detectors, being all solid state, have only two electrical failure modes: open circuit and short circuit. Both of these conditions can be caused only by mechanical means and are minimized by rigid mounting. Figure 8-33 shows the construction and mounting details.

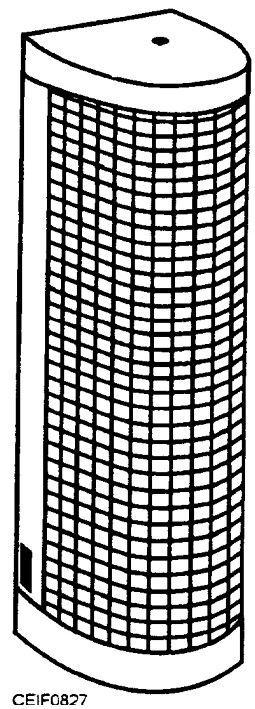


**Figure 8-27.—Ultrasonic motion detector.**

## Ultraviolet-Radiation Fire Detectors

Ultraviolet-radiation fire detectors combine large-scale integration circuit techniques with an ultraviolet detection assembly to form a simple, yet flexible, fire-detection system.

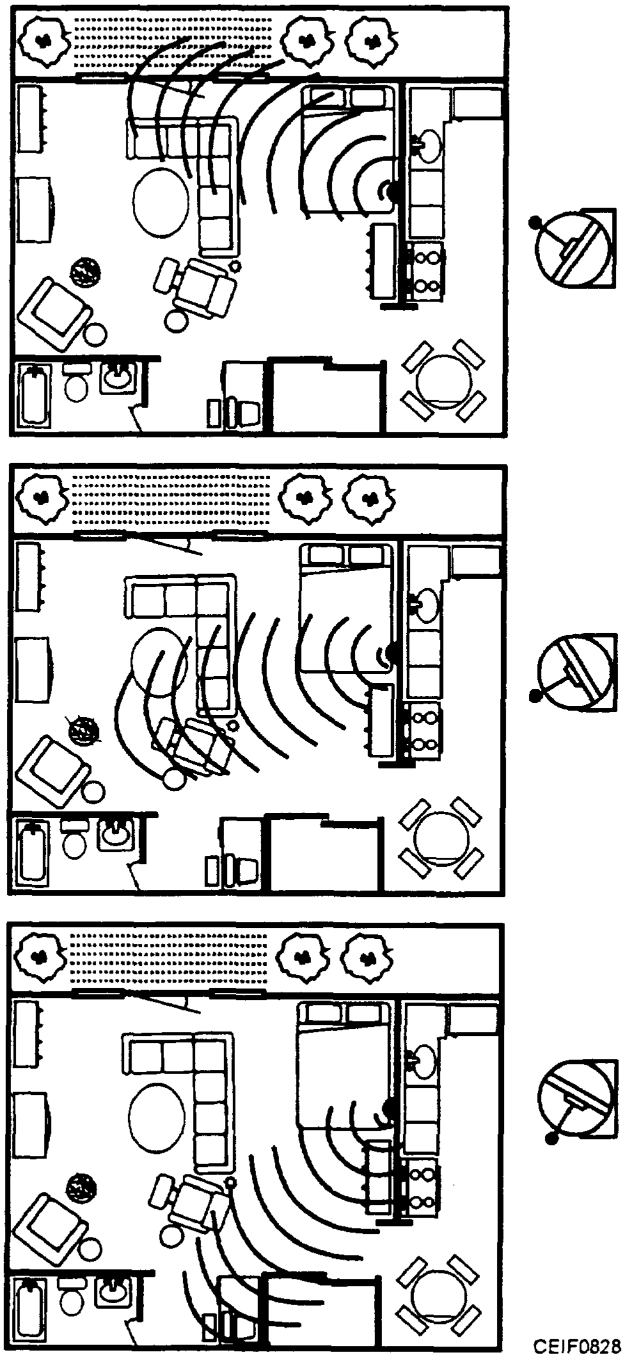

Figure 8-28.—Motion detector rotating up to 180° for maximum coverage.

The basis of this type of system is a gas-detection tube using the Geiger-Mueller principle to detect radiation wavelengths extending from 2000 to 2450 angstroms (Å) (1 Å = $10^{-8}$ cm). Figure 8-34 displays the radiation sensitive area of the tube and compares this area to other forms of radiation. It should be noted that visible radiation does not extend into the sensitive area of the detector. Similarly, radiation from artificial lighting sources does not extend into the sensitive area of the detector.

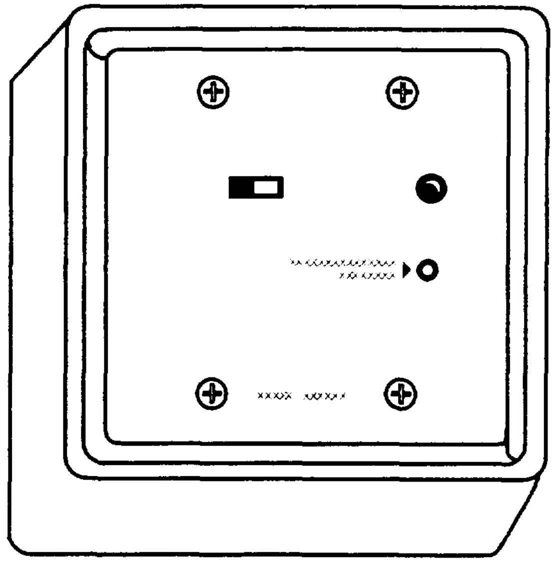

**Figure 8-29.—Audio detector.**

Welding arcs and lightning strikes, however, will generate radiation to which the detectors are sensitive and precautions must be taken to minimize these effects.

The ultraviolet-radiation detector's focus of sensitive points is a 60-degree spherical cone whose apex lies at the detector tube. Figure 8-35 indicates the relationship between viewing angle and relative sensitivity. The sensitivity of the detector tube is a characteristic of its cathode material and is fixed, but its voltage-pulse output rate varies both with flame size and flame viewing distance. The pulse output rate is directly proportional to flame size; that is, it increases when larger flame fronts are presented to the detector. The pulse output rate is also inversely proportional to the distance of the flame front from the detector tube-the pulse output rate decreases as the distance from the detector tube to the flame front increases.

To illustrate, a l-foot (0.09 $m^2$) hydrocarbon fire will cause a pulse output rate of 3 pulses per second at a viewing distance of 30 feet (8 m). This same fire will cause a tube pulse output rate of 20 pulses per second at a viewing distance of 20 feet (6 m). In a like manner, 1-foot (0.09 $m^2$) flame front must be located at a distance of 5 feet (1.5 m) to create a pulse output rate of 30 pulses per second; a 16-foot (1.4 $m^2$) fire will create the same pulse output rate at a distance of 25 feet (7.6 m), and so forth.

### Telephone Dialers

A schematic wiring diagram of a typical telephone dialer is shown in figure 8-36. The two cooperating

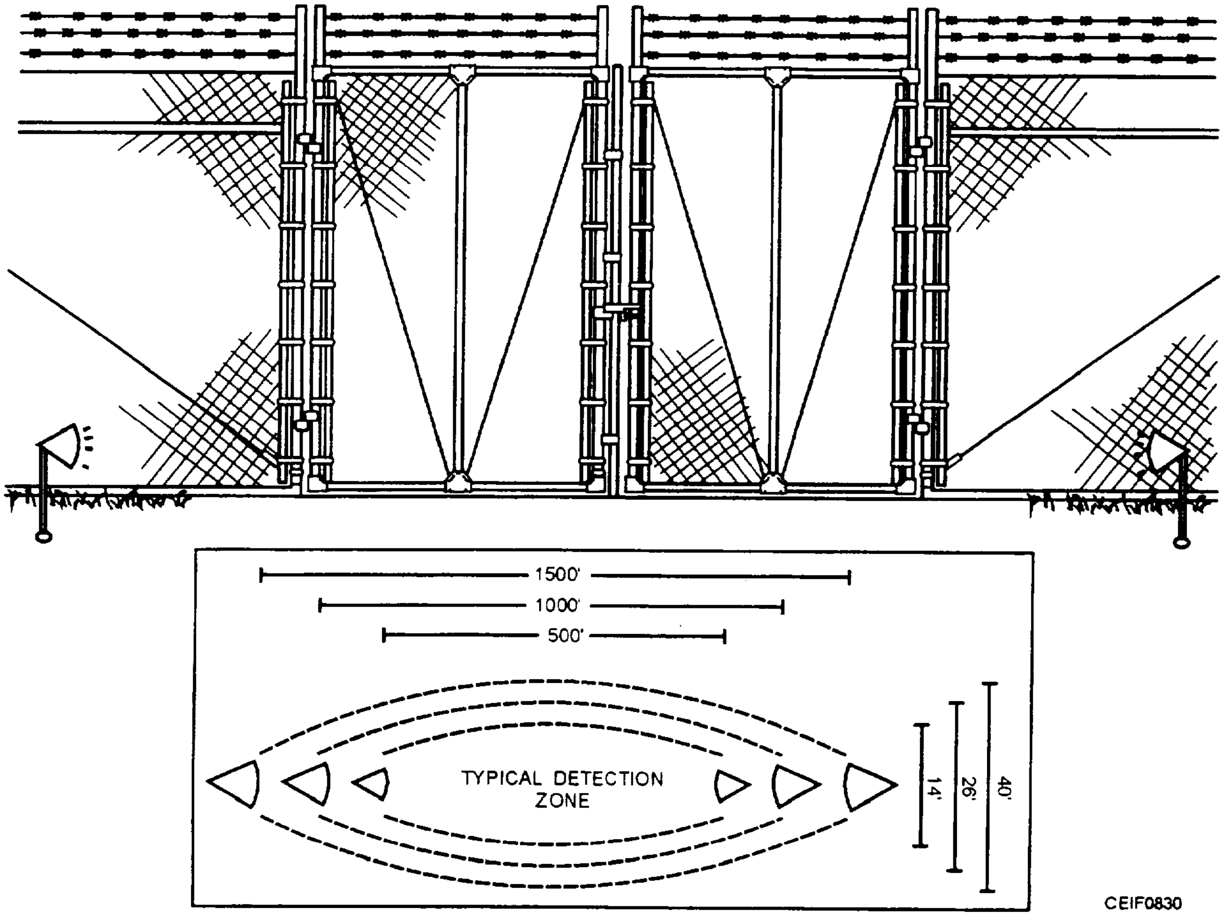

Figure 8-30.—A solid, circular beam of microwave energy extends from a transmitter to the receiver over a range of up to 1,500 feet (457 m).

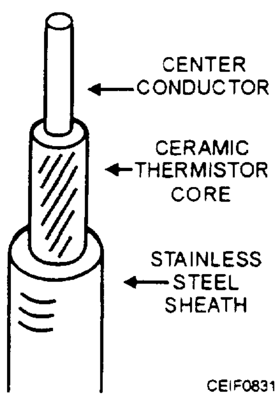

Figure 8-31.—Structure of a heat-sensor cable.

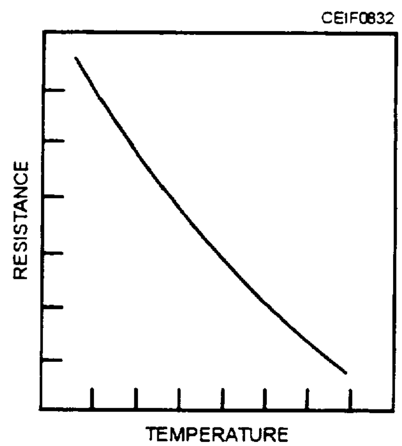

Figure 8-32.—Curve showing relationship of resistance to temperature.

channels of the dialer permit two distinct dialing and message programs. Although labeled as, and most commonly used for, separate burglar and fire alarms the two channels can be connected and programmed for any application: medical emergency, heating-system failure, freezer warmup, and water-pressure failure.

It is important to understand the priority relationship between the two channels before making trigger connections. The priority arrangement ensures transmission of the vital fire-alarm program (or other priority program on the FIRE channel) in three ways.

1. If the dialer is already operating on the BURGLAR channel when the FIRE channel is triggered. the dialer immediately switches to FIRE-channel transmission

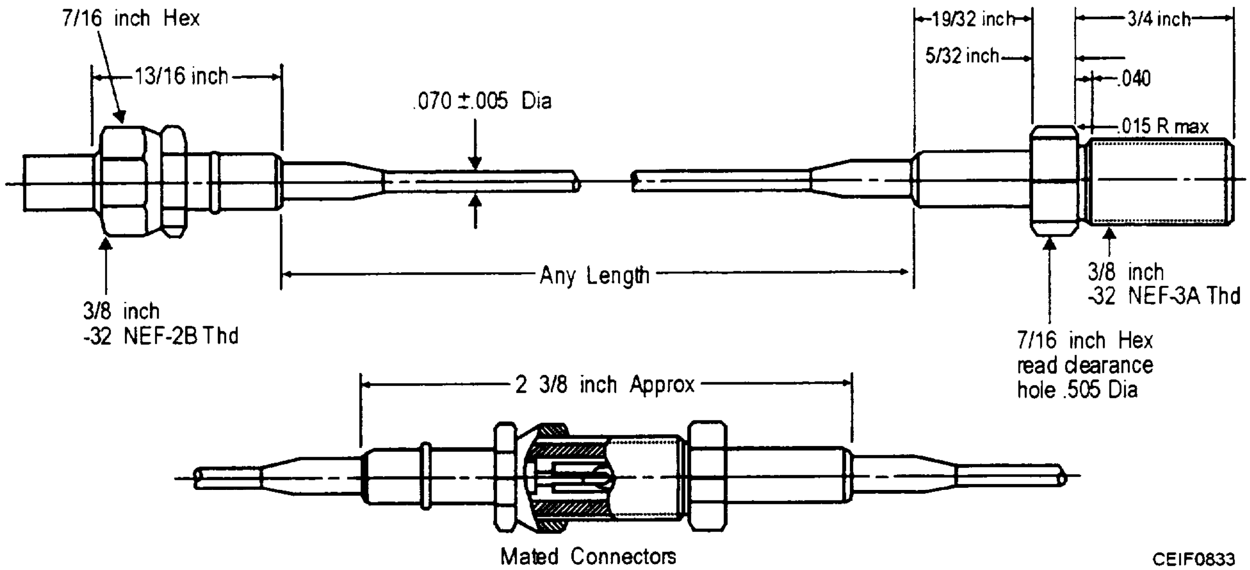


**Figure 8-33.—Using connectors to supply desired length of sensor cable.**

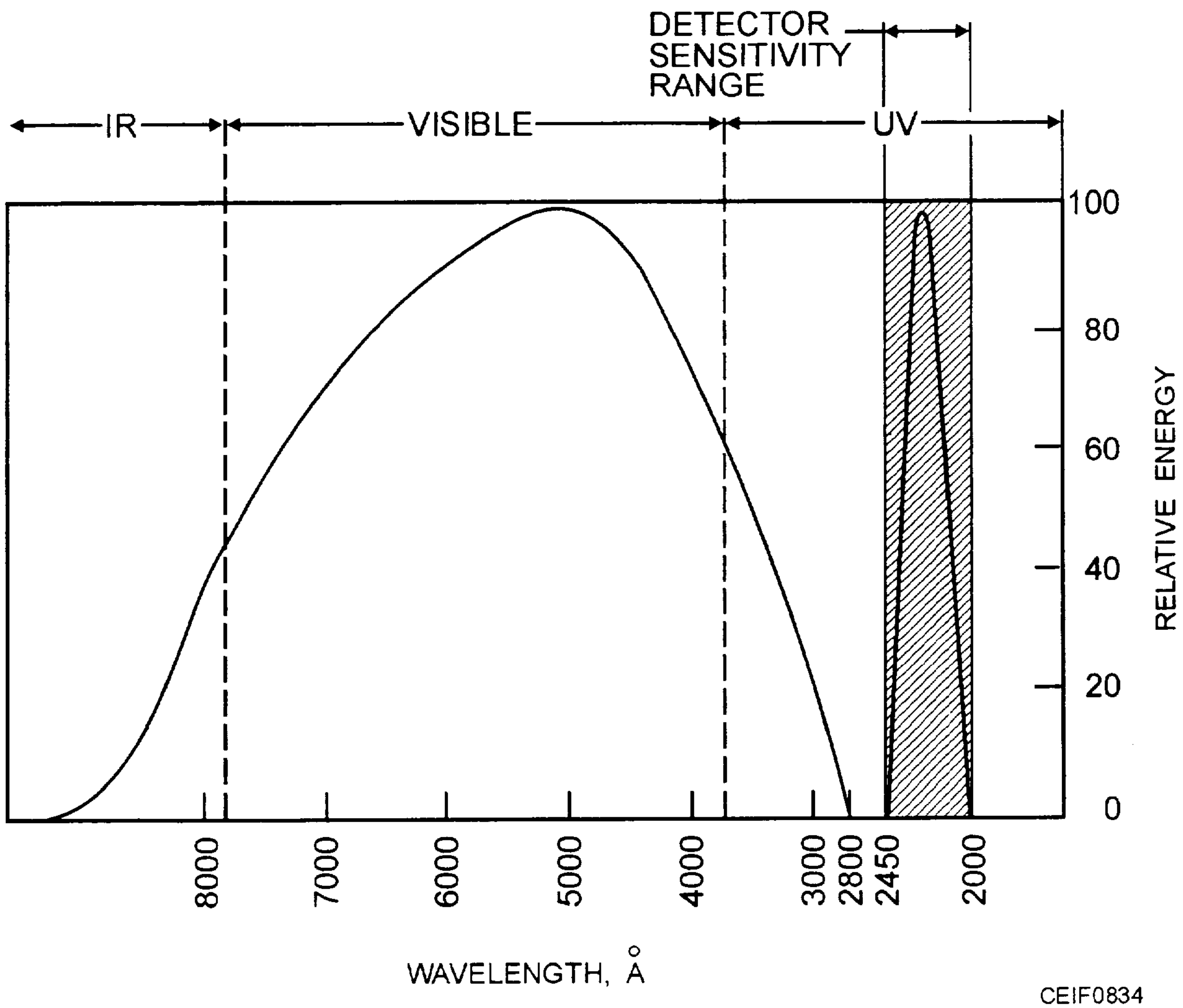


**Figure 8-34.—This detector has maximum sensitivity in the ultraviolet range.**

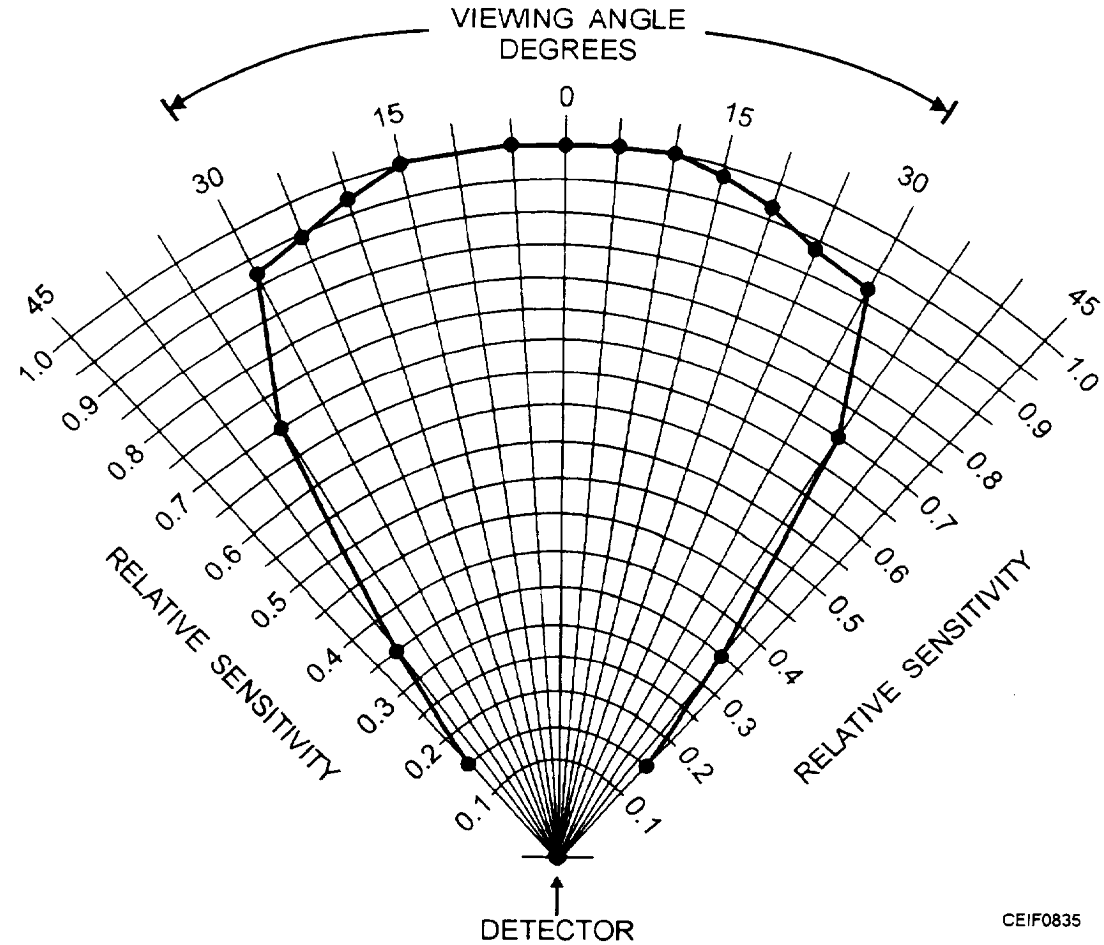


**Figure 8-35.—Viewing angle of ultraviolet motion detector.**

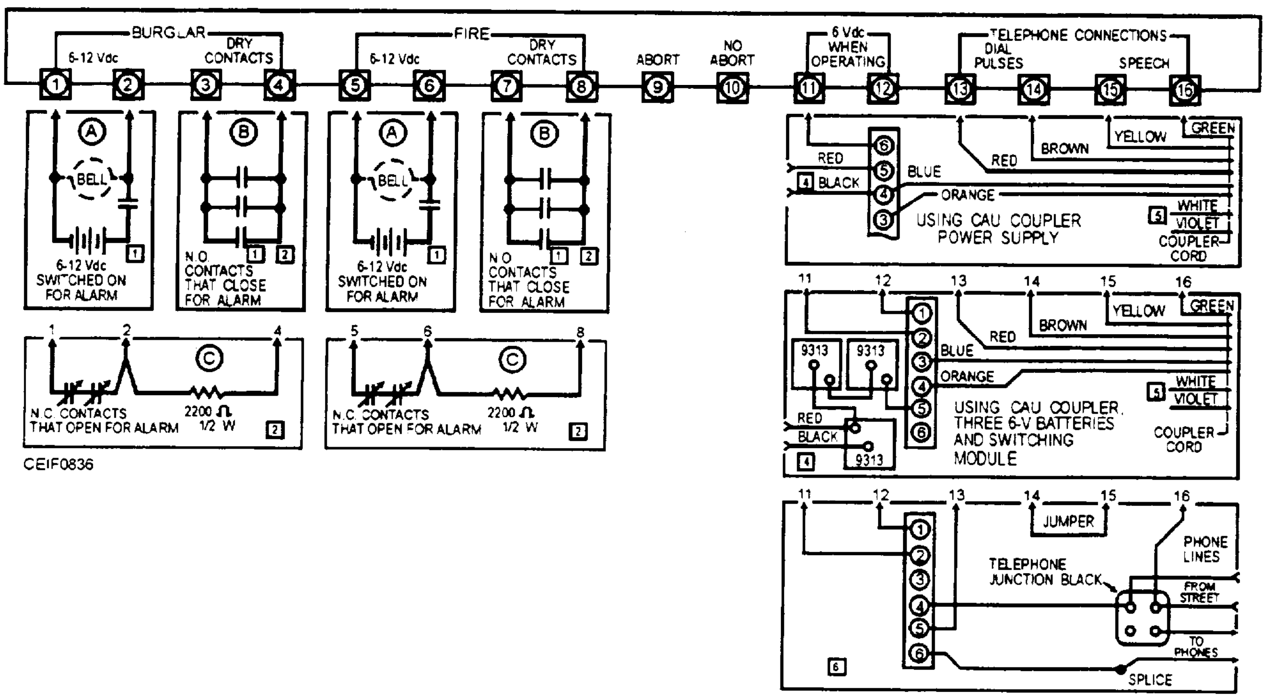


**Figure 8-36.—Schematic wiring diagram of a typical telephone dialer.**

2. When FIRE-channel priority seizure has occurred, the dialer overrides its normal end-of-cycle stop and runs for another full cycle. This ensures transmission of the entire priority program, even if the FIRE-channel take-over occurred near the end of a BURGLAR-channel cycle.

3. Even if the dialer has stopped after transmitting the full BURGLAR-channel program and the burglar-alarm input is still present, an input on the FIRE channel causes immediate transmission of the FIRE-channel program.

Each of the channels of the dialer can be triggered by a switched dc voltage, a dry-contact closure, or a dry-contact opening. The trigger inputs may be either momentary or sustained. In either case, the dialer transmits its full program, then stops and resets itself. An input that is still present when the dialer stops must be removed briefly and then applied again to restart transmission on that channel. A sustained input does not make the dialer transmit or interfere with normal use of the telephones, nor does it interfere with triggering and operation of the dialer on its other channel.

When available, an appropriate dry-contact closure should be used instead of a switched voltage for the dialer-trigger input. Figure 8-37 shows the preferred connections for a typical telephone dialer.

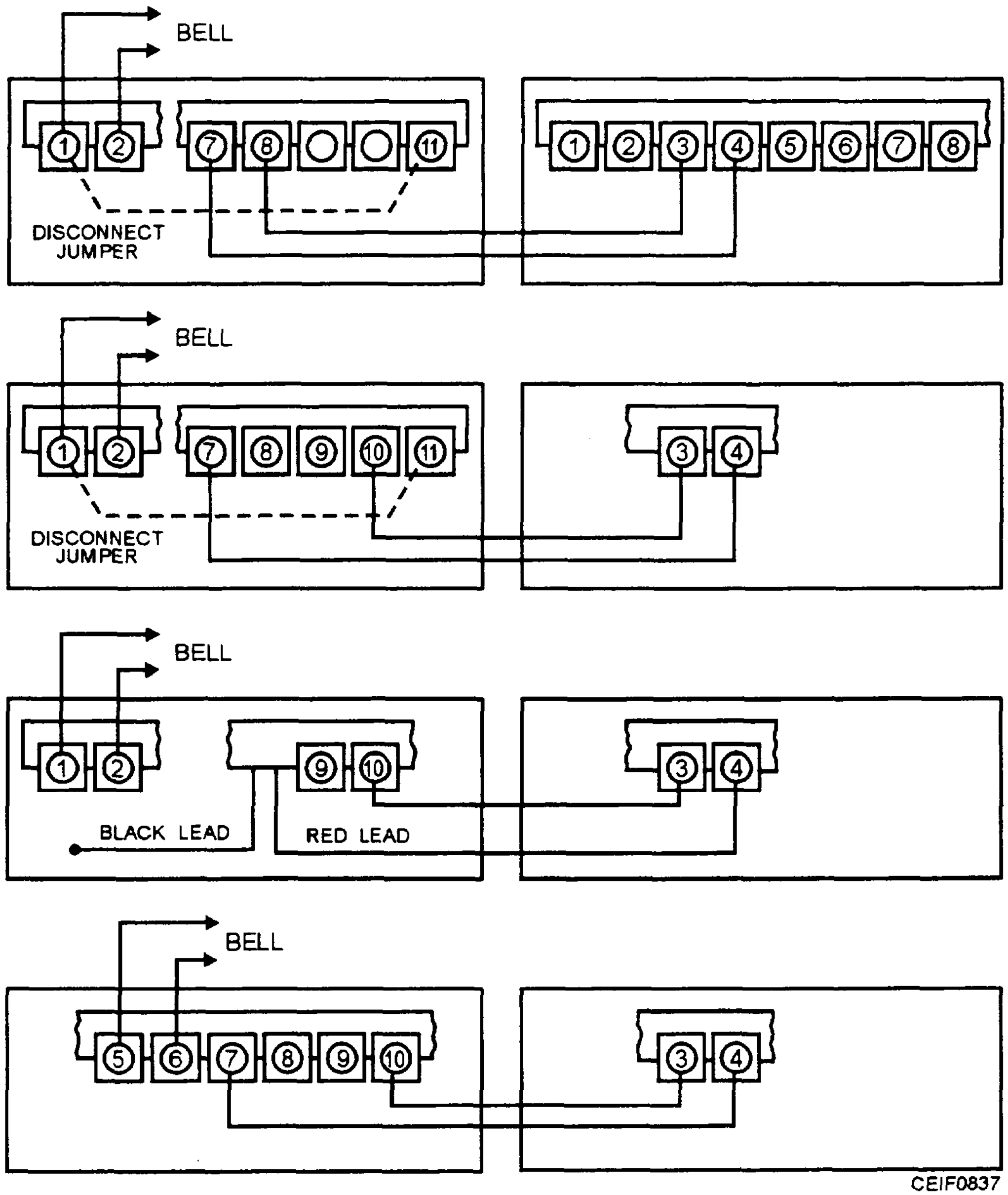


**Figure 8-37.—Preferred connections for a typical telephone dialer.**

Where the contacts of a police-connect panel are needed for polarity reversal, the contacts may be used to provide a switched-voltage trigger for the dialer, as shown in figure 8-38. This hookup lets the panel's BELL TEST feature be used without causing any dialer transmission.

When using the bell output of an alarm panel as a switched-voltage trigger for the dialer, always run the trigger wires directly from the dialer input terminals to control the panel terminals. Do not run the wires from the dialer inputs to the bell, horn, or siren locations; and do not route the sounding-device wires through the cabinet. Figure 8-39 shows the correct wiring for this hookup. In this hookup, dialer terminals 2, 5, and 6 are connected together within the dialer. This permits a simplified three-wire trigger connection from the control panel.

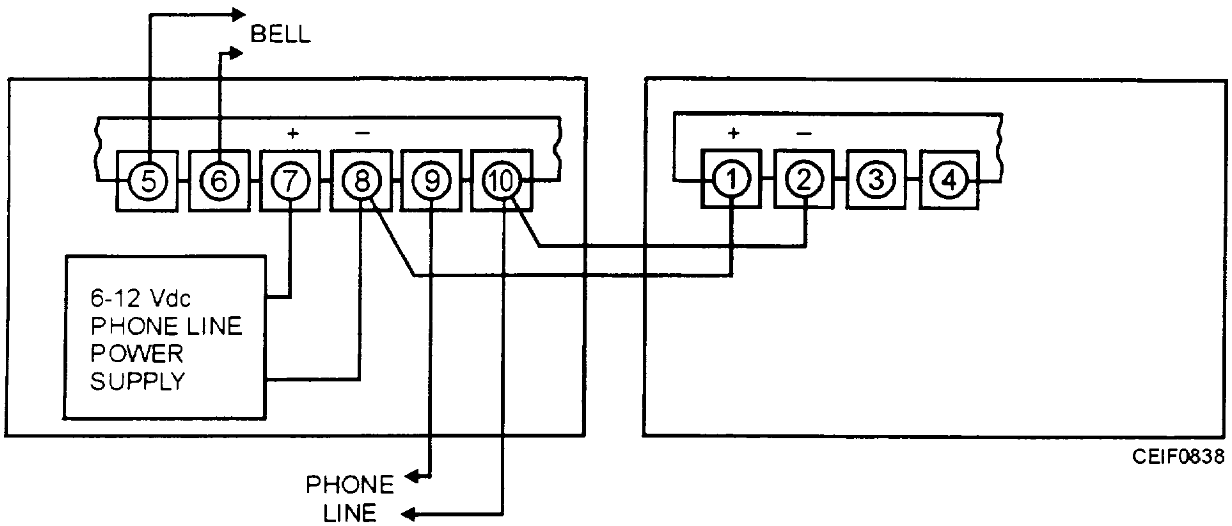


**Figure 8-38.—A switched-voltage trigger connected to a telephone dialer.**

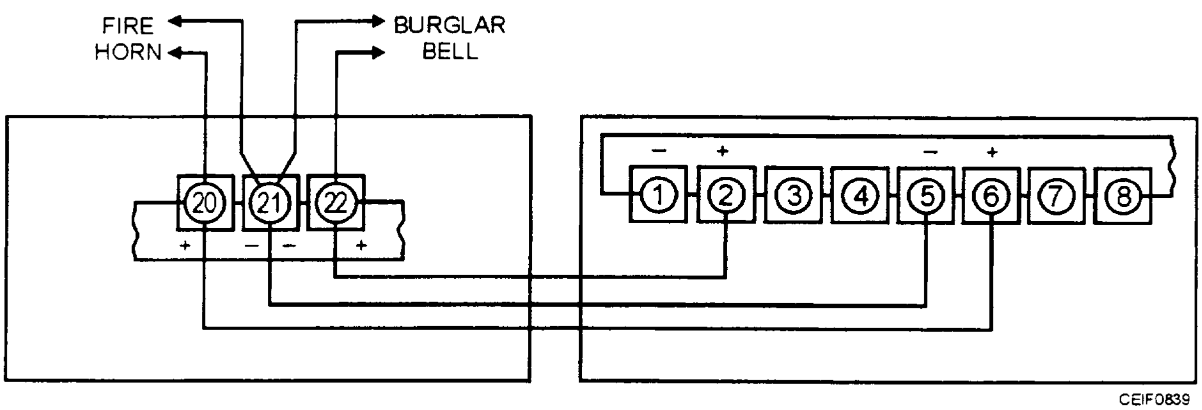


**Figure 8-39.—Wiring diagram for a switched-voltage trigger.**